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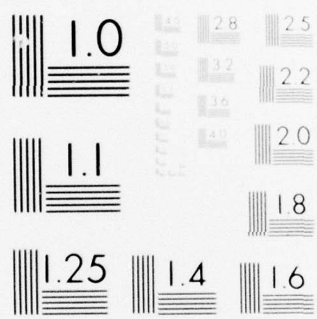


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Technical Report No. 243

# CONTINGENCY PLANNING FOR THE IMPACT OF OIL SPILLS IN DIFFERENT COASTAL ENVIRONMENTS OF CANADA

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# CONTINGENCY PLANNING FOR THE IMPACT OF OIL SPILLS IN DIFFERENT COASTAL ENVIRONMENTS OF CANADA

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## ABSTRACT

*Planning for a cleanup operation of the shore zone requires consideration of the physical nature of the coast (including the sediment types), wave energy levels, and tidal range. Beaches exist in a dynamic state and are continuously changing in response to littoral processes. In addition to these temporal variations, there is frequently considerable variability of shoreline types and process characteristics within a small region. In eastern Canada, contingency planning must cover rocky shorelines, sand beaches, and muddy coasts. There also is a wide range of littoral process environments, from the exposed Atlantic coast to the sheltered Bay of Fundy, which has tidal ranges on the order of 10 to 15 meters. Three examples from eastern Canada illustrate the variability of shorelines and processes in the context of cleanup planning.*

## INTRODUCTION

During the 10 years since the first large-scale cleanup program, which followed contamination of the coasts of England and France by the spill of crude oil from the tanker *Torrey Canyon*, a large number of major spills have occurred throughout the world. Despite the experience that has been gained, there is considerable room for improvement in contingency planning. This discussion will focus on one method by which improvements could be made, that is, by reconnaissance surveys of environments in areas where there is a high risk of coastal oil spills.

The major factors that determine the effects of a large spill on a coast are the volume of oil in the spill, the type of oil involved, the climatic and meteorological conditions at the time of the spill, the characteristics of the littoral energy environment (waves and tides), and the geological character of the coastal environment. Although much is known about the behavior of different types of oil under different conditions, because of the number of variables involved the first three factors are basically unpredictable. The last two factors can be predetermined from field work or from reconnaissance surveys. They can be used as the basis for local and regional contingency plans by providing estimates of how and where the oil will be deposited, the persistence of the oil, the suitability of cleanup techniques to a particular location, and the availability and cost of those techniques.

Three examples from very different coastal environments in eastern Canada will be used to illustrate the importance of understanding the variability of littoral processes and of geological parameters in planning cleanup programs:

1. the south coast of Chedabucto Bay is essentially a rocky coast on which there are a few pocket beaches of pebble-cobble sediments. In this instance, contingency plans need only allow for two types of shoreline in a single littoral energy environment.
2. the sandy beaches of the Madgalen Islands represent only one shoreline type but have two distinct littoral energy environments, so that two plans are necessary even though the shoreline type is uniform.
3. in marked contrast to these relatively simple coastal environments, the Bay of Fundy has a large number of shoreline types and littoral energy conditions that vary considerably. The contingency plan for that area must include specific cleanup responses to accommodate each environment.

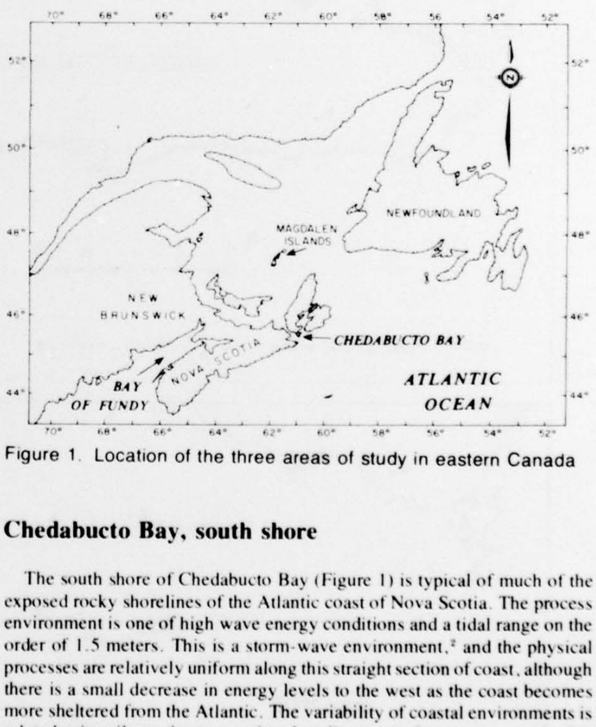


Figure 1. Location of the three areas of study in eastern Canada

## Chedabucto Bay, south shore

The south shore of Chedabucto Bay (Figure 1) is typical of much of the exposed rocky shorelines of the Atlantic coast of Nova Scotia. The process environment is one of high wave energy conditions and a tidal range on the order of 1.5 meters. This is a storm-wave environment,[2] and the physical processes are relatively uniform along this straight section of coast, although there is a small decrease in energy levels to the west as the coast becomes more sheltered from the Atlantic. The variability of coastal environments is related primarily to the two major shoreline types that are present in this section.

This straight shoreline is a fault-line coast that is characterized by low, resistant cliffs and intertidal rock platforms. The uniform character is interrupted by small bays that have been formed by wave erosion along secondary faults or other lines of weakness. The rocky coast is largely devoid of sediment; the only deposits occur within the bays and form pocket beaches of pebble-cobble material. Very little material is supplied to the coast, so that the rate of sediment accumulation is very slow.[3]

The deposition and fate of oil on exposed rocky coasts is very different from that on the beaches of the small bays. Oil coats the surface of the rocks and the intertidal algae and collects in supratidal rock pools if contamination occurs during periods of high water levels (spring tides or storms). The trapping of oil in the supratidal rock pools is particularly important because oil is stored there until released by a subsequent high water level. Recontamination of adjacent shorelines that may already have been cleaned (naturally or by a cleanup operation) may occur. Removal of oil from rock surfaces or rock pools is usually a slow and difficult operation requiring manual techniques in different terrain. However, in this high-energy environment, natural self-cleaning is rapid and usually effective.

Figure 2 shows those sections of shoreline that were contaminated following the spill of Bunker C oil from the tanker *Arrow* in 1970. The upper diagram indicates all locations where oil was observed in the shore zone between March and June 1970. The lower diagram shows the actual distribution by the end of June 1970. On high-energy, exposed rocky coasts, wave action abrades and disperses the oil. In addition to this mechanical action, weathering processes, such as chemical oxidation and microbial attack, are accelerated, and the shoreline is cleaned naturally within a few months.

By contrast, virtually all types of oil deposited on the pocket beaches would permeate the pebble-cobble sediments, making it necessary to remove a sediment-oil mixture using a tracked vehicle or a front-end loader. Graders could not be used on this type of beach. At one site on this coast (Indian Cove, in Fox Bay) studied following the *Arrow* spill, the beach was contaminated near the high-water level to depths up to 20 cm.[3, 6] The beach was recontaminated on several occasions by oil released from adjacent rock pools during high spring tides.

Removal of sediment from this pocket beach led to lowering of the surface by as much as two meters. Because no sediment was available to naturally replace what was lost, waves washed over the beach crest, and within 12 months the beach crest had retreated between 10 and 20 m. Sediment removal must be avoided in this type of environment unless the beach material is replaced by equal amounts of similar-sized sediment. In the example from Indian Cove, more damage resulted from the removal of sediment during cleanup than had occurred originally from the contamination. The persistence tme of oil in these small bays is high because they are set back from the main trend of the exposed coast and, therefore, are sheltered from wave activity.

On cobble beaches, oil that is deposited on the upper beach during storms is unaffected by normal wave action. Inasmuch as the oil is not subject to abrasion, it will degrade very slowly. Subsequent storm waves may erode the beach and deposit cobbles on the upper beach, thus burying the oil layer (Figure 3). The beach may appear clean on the surface, but substantial amounts of oil may merely have been covered (Figure 4).

**Summary.** Exposed rock coast: natural cleaning is rapid except above the limit of wave activity; cleanup operations would require manual removal of oil from pools to prevent redistribution. Pocket beaches: sheltered from waves; therefore, oil persists longer and natural cleaning is less effective; oil would permeate pebble-cobble sediments; if cleanup is necessary it would require removal of oil-sediment layer up to 60 cm deep and replacement by material of similar size; graders could not be used; tracked vehicle would be required for mechanical cleanup.

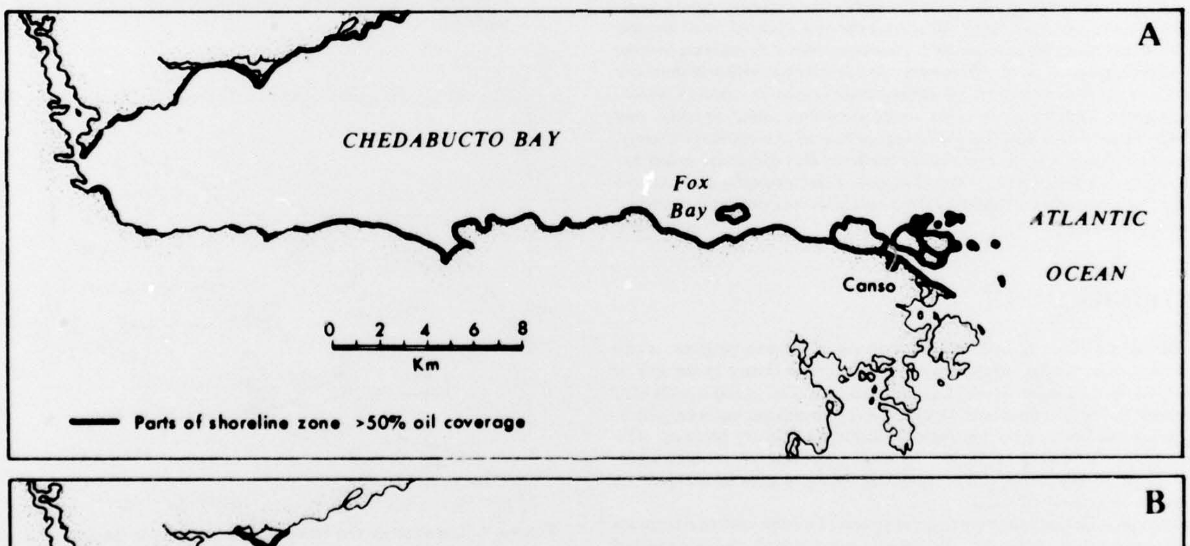


Figure 2. Distribution of oil residues on the south shore of Chedabucto Bay; (A) a compilation of all locations where oil was observed between March and June 1970; (B) oil residues in the shore zone in June 1970, from ground and aerial observations (adapted from Owens and Rashid[3])

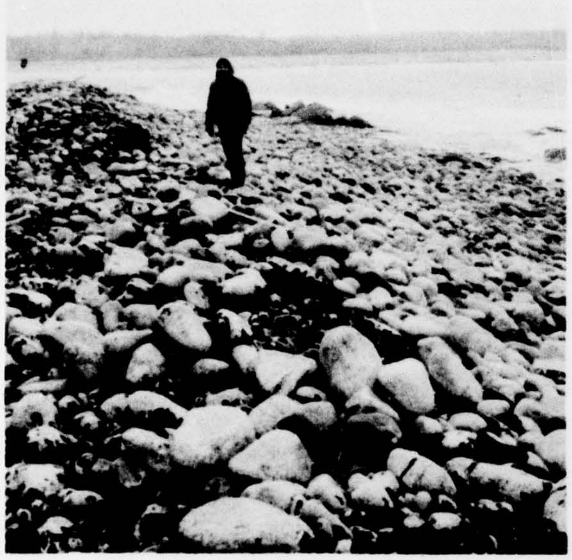

Figure 3. Cobble beach, Chedabucto Bay: this beach was severely contaminated during the spring of 1970; the photograph, taken in the spring of 1973, shows that the oil deposited above the high water mark had undergone little abrasion during the three-year period, but that it was being buried by material thrown up onto the top of the beach by the action of storm waves

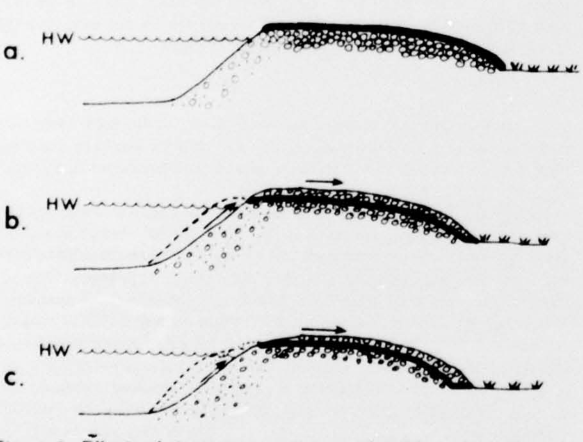


Figure 4. Effects of storm-wave action on oil residues deposited on a cobble beach; in (a) oil is deposited above the high water mark (HW); (b) a subsequent storm will erode the intertidal beach and waves will push the cobbles onto the upper beach to cover the oil deposit; (c) a second storm will continue this process, gradually exposing more of the buried oil-sediment layer

## Magdalen Islands

The Magdalen Islands, located in the central Gulf of St. Lawrence (Figure 1), consist of a series of barrier beaches that connect small bedrock outcrops (Figure 5). Because the tidal range is less than one meter, wave energy is concentrated in a narrow vertical band. The wave climate is dominated by locally-generated wind waves. Wave energy levels are higher on the west coast in all seasons owing to the prevailing onshore winds on that coast.[4] The characteristic feature of the west coast process environment is the seasonal variation in energy levels due to the higher frequency of storms in winter months. Wave energy levels also are higher in winter than in summer months on the east coast, but the seasonal variations in wave height are overshadowed by the effects of storm waves, which produce large, short-term variability throughout the year.

Both coasts have long, straight sand beaches; therefore, in terms of shoreline types and sediment characteristics, the west- and east-facing barriers are similar. The differences that have been reported[4] result from the contrast in the littoral energy environments. The effects of a major spill in the vicinity of the Magdalen Islands would be very different on the west than on the east coast, making it necessary to have two response plans available. Oil would be deposited in the same manner and at the same locations on the beach in these two environments. Owing to the small grain size of the sediments, the oil will not penetrate the beach unless it is fresh crude or a very light grade petroleum.

Mechanical cleanup with graders would not be easy on the western barriers as the beach is too narrow (20 to 30 m) and beach gradients are frequently too steep, particularly during winter months. It is likely, therefore, that tracked vehicles, front-end loaders, or even manual techniques would be necessary on this coast. Graders most probably could be used on the wider, flatter eastern barriers.

One problem on the east coast would occur if the oil were deposited during storm-wave conditions. The eroded beach would recover very rapidly inasmuch as accretion has been observed within two or three days following a storm.[7] Unless oil were removed quickly from these east coast beaches, it would be buried by sand bars that migrate onto the beach during the post-storm recovery phase (Figure 6). Cleanup would then involve excavation of the beach to remove the oil (Figure 7). The persistence time of oil on the two beaches would also be very different. With higher wave energy levels on the west coast, the mechanical and chemical breakdown of oil in the littoral environment would be more rapid.

The most important aspect of the sand beaches of eastern Canada and many parts of the east coast of the U.S. is that the beaches are very mobile as a result of storm wave activity and post-storm accretion. The constant movement of sediments would lead to burial of oil in some locations, whereas in others it would be eroded. If cleanup is necessary it should, therefore, be carried out as soon as possible after the oil reaches the beach.

**Summary.** Oil would affect both beaches in a similar manner, but different cleanup techniques would be required. On the west coast, the beach generally is narrow and steep so that graders could probably not be used; tracked vehicles or manual techniques would be required. Because of high wave energy levels, dispersal and chemical degradation would be relatively rapid. On the east coast, graders probably could be used. If the beach is contaminated during storm conditions, oil residues would probably be buried within two or three days. Because wave energy levels are lower than on west coast, residues persist longer.

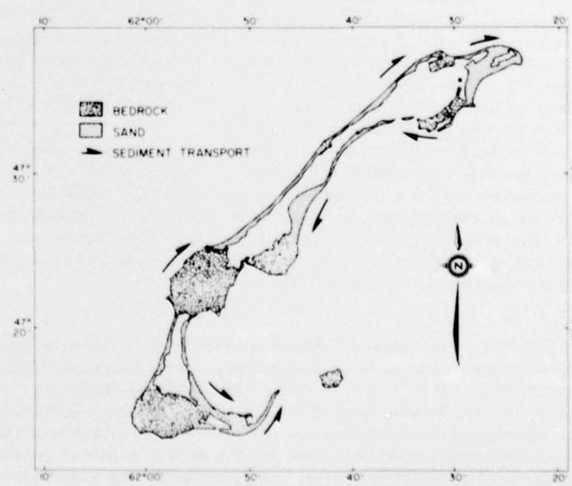


Figure 5. The Magdalen Islands, Quebec; distribution of barrier beaches and directions of sediment transport

Figure 6. Sand beach, Chedabucto Bay: the beach was covered by a thick deposit of oil on the upper parts of the intertidal zone; this photograph, taken a month after the oil had been laid down, shows that most of the oil was buried by sand with only the outer portion of the oil-sediment layer exposed (see Figure 7f)

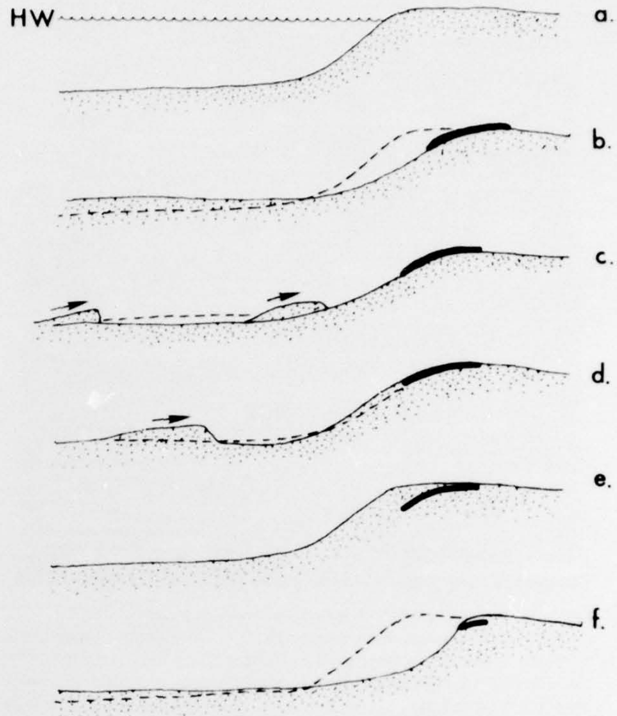


Figure 7. Effects of storm-wave action on oil residues deposited on a sandy beach: (a) the pre-storm beach; (b) oil is deposited on the upper beach after a storm has eroded the intertidal beach; (c) post-storm recovery commences and sand migrates back into the intertidal beach; (d) and (e) the sand then will cover the oil deposit; (f) a later storm will expose the buried oil-sediment layer

## Bay of Fundy

Planning response tactics at the local level takes into account variations in shoreline types and process characteristics. Preparation of contingency plans at the regional level involves a much wider range of responses in order to include all the local aspects. In the Bay of Fundy, which has a coastline of approximately 1,400 km, six major coastal environments have been identified (Figure 8, Table 1). Each of the coastal environments either has distinctive physical parameters (geology or geomorphology) or distinctive processes (waves or tides) that distinguish it from the other coasts of Fundy.

Planning for oil spill cleanup of the coast also requires a knowledge of shoreline types. In this region 12 major types of shoreline have been recognized (Table 2). Oil deposition and persistence are different in each shoreline type, and each type could occur in any of the six coastal environments although, for example, marshes occur primarily in the sheltered areas of Minas Basin and Chignecto Bay, whereas sheltered, resistant coasts are more common in the northwestern shore environment (particularly Passamaquoddy Bay). It is not possible to discuss each of the coastal environments or the shoreline types, and so two examples will be considered briefly: the Head of the Bay, which has resistant cliffs, large embayments, and bay beaches; and the Minas Basin, which is characterized primarily by intertidal sand or mud deposits and by marshes in sheltered areas.

**The Head of the Bay.** This coastal environment (Fig. 9) has two major shoreline types: resistant rocky cliffs and large cobble beaches in the three embayments. Oil on rocky coasts has been discussed briefly above in connection with the south shore of Chedabucto Bay. One major difference in the Bay of Fundy environment is that littoral processes are dominated by the effects of the tides. In the Head of the Bay area the tidal range is on the order of nine to 12 m, so that wave energy is dissipated over a wide vertical range. Also, this is a sheltered wave environment, and levels of wave energy initially are lower than on the exposed Atlantic coast. Mechanical abrasion of intertidal oil residues is therefore much slower in this area. Most of the rocky sections of coast are inaccessible, and cleanup would be considered only if large amounts of oil were trapped in rock pools and threatened to contaminate adjacent marshes or beaches.

An idealized cross section across one of the bay-head beaches that occur in each of the three large embayments shows a distinct change in sediment types between the low-water mark and the marsh. The storm ridge of cobble material gives way seaward to a very steep beach of pebble-cobble sediments. This is replaced in the lower foreshore by an almost flat mud deposit that is up to 1,000 m wide in places (Figure 10 and 11). Oil would be deposited mainly on the coarse sediments, where it would penetrate the surface material. As the mud flats are wet even when exposed at low tide, oil on the surface would be refloated by the flood tide. However, oil that collects in depressions or permeates the mud, through burrow holes, etc., would be rapidly covered by a mud veneer after only one or two tidal cycles. Once buried, this oil would persist because of lack of mechanical abrasion and anaerobic conditions that prevent oxidation and microbial degradation.

Amounts of oil on the central and upper sections of the beaches would probably be very large in these three embayments. Wind-driven surface currents are primarily from the west-southwest and are generated by the prevailing and dominant westerly winds along the axis of the bay. The embayments face the west or southwest and are bounded by rocky headlands. Any slicks that entered the three embayments would be trapped, and the oil most likely would be deposited on the bay-head beaches. These bay-head beaches would present a problem for a cleanup program because oil almost certainly would be trapped in rock pools on the rocky coasts adjacent to the beaches, and the problem of recontamination would be very real. Access to these rocky headlands is difficult and often dangerous owing to the rapid speed with which the flooding tide rises. Removal of contaminated sediments from the beaches would lead to an unstable condition inasmuch as the input of sediment to replace that which would be removed would be very slow. Replacement of the material would be necessary to avoid initiating any erosion.

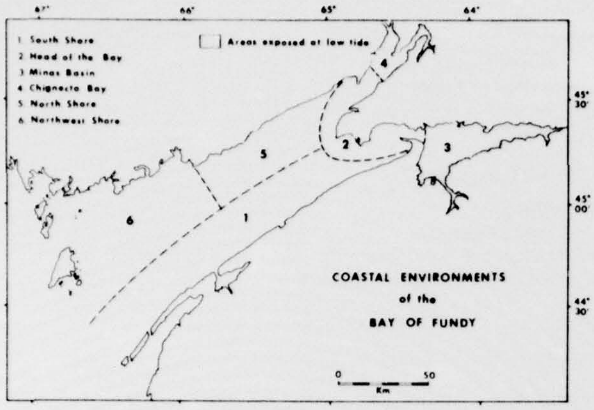


Figure 8. Subdivisions of the Bay of Fundy shoreline into six coastal environments

It is clear that in this instance many factors must be considered before a cleanup operation could be initiated. It is also important that each of the points discussed briefly above is predictable, so that a practicable contingency plan for this environment can be prepared in advance.

**Minas Basin.** The characteristics of the shoreline of the Minas Basin are extremely varied, ranging from sandstone cliffs to marshes and from wide intertidal sand flats to rock platforms. Two of the most common combinations of shoreline types are mud flats or sand flats backed by either unresistant till cliffs or marshes (Figure 12). The tidal range is greater than 10 m; a maximum of 16 m has been recorded in places during spring tides. This large tidal range, coupled with low coastal zone gradients, gives a wide intertidal zone that is exposed at low tides (Figure 8). Where present, the intertidal deposits are either sand or mud and rest on a wave-cut till and/or bedrock platform.

The mud flats rarely are completely dry at low tide and frequently have a thin film of water on the surface of the sediments. Oil deposited on the surface would be refloated by rising tide and carried elsewhere. As noted above, any oil that is buried would be protected from mechanical, chemical, and microbial degradation and will, therefore, persist for a long time unless subsequently exposed by changes in bottom morphology.

**Table 1. Characteristics of the coastal environments of the Bay of Fundy**

| Subdivision | Geological character | Backshore relief | Beach character | Fetch and wave exposure | Mean tidal range | Sediment availability |
|---|---|---|---|---|---|---|
| 1. South Shore | resistant basalt dyke parallels | low rocky coast or cliffs up to 30 m | absent or narrow cobble beach at high water mark, with wide intertidal platform | sheltered (50 km) | 6 to 10 m | very sparse |
| 2. Head of the Bay | [illegible]nt rocks; basalts or granites | cliffed coast, up to 200 m | absent or large pocket beaches of peb/cob on beachface and mud overlying coarse sediments in intertidal zone | exposed (50-100 km) | 10 m | sparse, but locally abundant |
| 3. Minas Basin | sandstone and shales, or unconsolidated glacial deposits | cliffs, up to 30 m | wide intertidal mud or sand flats on rock platform, peb/cob beach at hwm; marshes in sheltered areas | very sheltered (<50 km) | >10 m | abundant |
| 4. Chignecto Bay | sandstones and shales | cliffs, up to 20 m | wide intertidal mud flats on rock platform, peb/cob beach at hwm; extensive marshes in sheltered areas | very sheltered (<50 km) | >10 m | abundant |
| 5. North Shore | resistant rocks, sedmentary rocks and intrusives, thin till cover | cliffs (west, 5 to 60 m; east, >100 m) | absent or coarse-grained pocket beaches | sheltered (<50 km | 6 to 10 m | very sparse |
| 6. Northwest Shore | resistant rocks, thin till cover | low rocky coast or cliffs, 5 to 30 m | absent or coarse-grained and narrow | outer coast exposed, rest sheltered (<50 km) | 6 m | sparse |

**Table 2. Shoreline types in the Bay of Fundy**

I. Rock or cliff shorelines

1. Exposed, resistant coast with low backshore or cliffs
   - with no beach or intertidal platform
   - with wave-cut platform devoid of sediments
   - with wave-cut platform and beach at high-water line
   - with wave-cut platform and intertidal sediments (see 9, below)
2. Sheltered, resistant coasts
3. Exposed, unresistant cliffs
4. Sheltered, unresistant cliffs

II. Shorelines with beaches

5. Cobble or mixed-sediment beaches
   - beach at base of cliff
   - beach with overwash
   - beach with inlet and/or lagoon
6. Sand beaches
7. Pocket beaches
   - on rocky coasts
   - in a large embayment
8. Beaches in sheltered environments

III. Shorelines with intertidal sediments

9. Coarse sediments on a wave-cut platform
10. Intertidal mud
11. Intertidal sand

IV. Shorelines with vegetation

12. Marshes



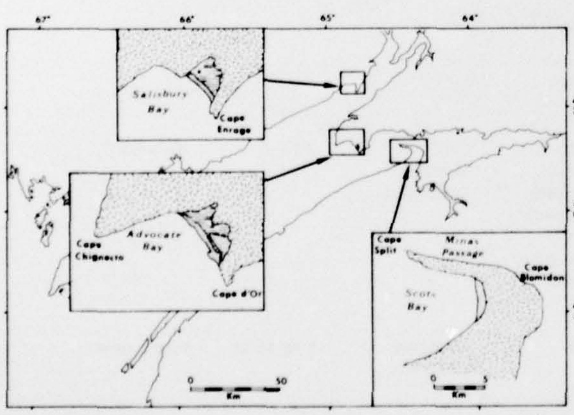


Figure 9. The Head of the Bay: this subdivision is characterized by three large embayments that are exposed to the southwest; each has a large pebble-cobble beach that is backed by marshes and fronted by mud flats (Figure 11)

Figure 10. A pocket beach on the north shore of the Bay of Fundy: although this beach is much smaller than those in the large embayments, it has the same sequence of cobble ridge-pebble/cobble intertidal beach-mud flats; the tidal range at this site is 7.5 m; the photograph was taken at low tide

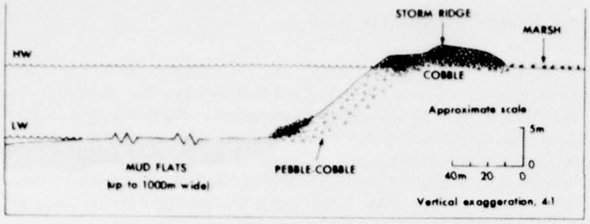


Figure 11. Idealized profile across the intertidal zone on one of the large embayment beaches in the Head of the Bay subdivision.

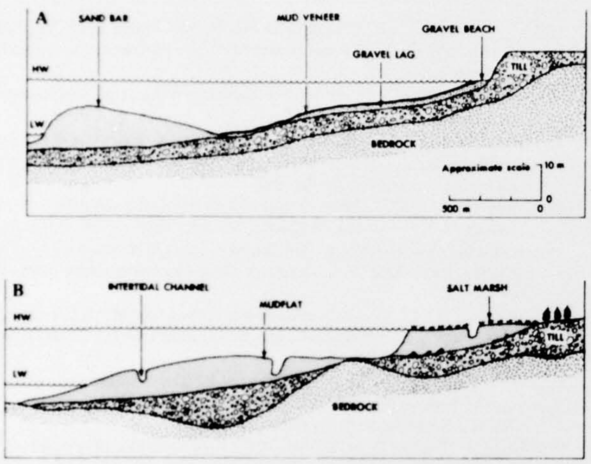


Figure 12. Idealized profiles across two of the major shoreline types that occur in the Minas Basin: (A) intertidal sand flats with a gravel beach at the highwater mark and an unresistant till cliff; (B) intertidal mud flats that give way to salt marshes above the high water mark (adapted from Dalrymple *et al.*,[1] Swift *et al.*[8])

Oil deposited on dry mud flats or sand flats would be subject to mechanical abrasion and burial. The sand deposits are in a state of constant motion, primarily in association with the strong tidal currents, which reach velocities up to 2 m/sec.[1] Although wave action is minimal inasmuch as this is a very sheltered environment, the high level of tidal energy generates rapid sediment transport. Sand grains are moved individually along the surface and mechanical abrasion results. Sand waves up to 2 m thick can be formed that migrate as a body across the sand flats (Figures 13 and 14). The migration of these sand waves or of mud deposits would lead to temporary burial of oil deposited in the intertidal zone. Cleanup on the mud flats would be almost impossible owing to the great difficulty of access for walking across mud flats is often very slow and exhausting. The sand flats can be traversed easily on foot, but operations would be complicated by the speed at which the rising tide crosses the wide flats, which often is faster than a person can run.

Where the intertidal deposits have a pebble-cobble beach and a till cliff in the upper foreshore (Figure 12, top), any oil deposited on the beach would only slowly be abraded. Wave energy levels are low in this environment, and the waves are active on the beach only for brief periods at the flood of the tide. Mechanical abrasion, however, may be less important in this environment than weathering. The small surface area and low adsorptive capacity of pebble-sized material would expose more oil to chemical oxidation and to photochemical and microbial weathering than would be the case on smaller sized sediments.

The till cliffs are composed largely of easily erodable unconsolidated clays, sands, and cobble. The beach acts as a buffer to protect the base of the cliff from erosion, so that removal of contaminated material from the beach could reduce the level of protection and could initiate a period of cliff erosion. If replacement of sediment is not possible, natural cleaning could be hastened by pushing the contaminated sediments down the beach toward the water line and allwing the rising tide to transport the material back up the beach. This technique would not lead to complete removal of the oil but would at least speed up the process of mechanical abrasion.

Figure 13. Sand waves in the intertidal zone of the Minas Basin: the distance between the crests of the waves is approximately 5 m, and the height of the sand waves is about 1 m; the sand waves are migrating from left to right in this photograph.

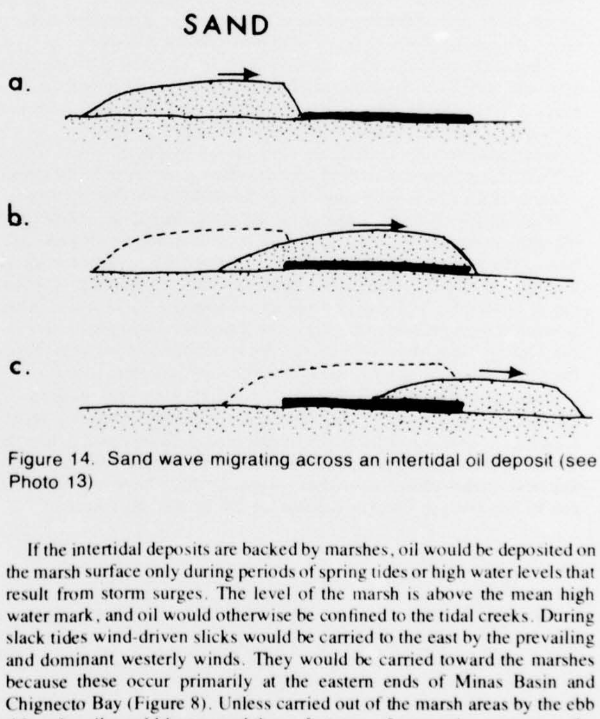


Figure 14. Sand wave migrating across an intertidal oil deposit (see Photo 13)

If the intertidal deposits are backed by marshes, oil would be deposited on the marsh surface only during periods of spring tides or high water levels that result from storm surges. The level of the marsh is above the mean high water mark, and oil would otherwise be confined to the tidal creeks. During slack tides wind-driven slicks would be carried to the east by the prevailing and dominant westerly winds. They would be carried toward the marshes because these occur primarily at the eastern ends of Minas Basin and Chignecto Bay (Figure 8). Unless carried out of the marsh areas by the ebb tides, the oil would be trapped there. In terms of preventive measures, the marsh areas should receive high priority inasmuch as cleanup is very difficult in this type of environment and they are very sensitive ecological systems in terms of both fauna and flora.

**Summary.** The Bay of Fundy includes a complex suite of shoreline types within six major coastal environments. At the Head of the Bay, the large embayments would act as traps for wind- or current-driven slicks moving from west to east. On mud flats in the lower foreshore, buried oil would not be subjected to mechanical, chemical, or microbial degradation. Manual cleanup before burial would be the only effective technique for oil removal. Oil should be removed from adjacent rock shores to prevent reoiling of cleaned sections. Removal of oiled sediments from cobble-pebble beaches would require replacement of the material.

In the Minas Basin area, sediments constantly are being redistributed in the intertidal zone, so that burial of oil is very probable. No practical or effective way to clean the intertidal zone is known. If material is removed from the base of unconsolidated cliffs, it should be replaced to protect cliff from erosion. Marshes would be better protected than cleaned.

## CONCLUSIONS

Many aspects of a spill, such as the type and volume of oil, will be unknown until the event occurs. Nor can the meteorological and oceanographic conditions be predicted accurately. Other aspects of spill behavior can be studied, though, as part of preparing contingency plans. Prediction of the movement of oil using modeling techniques is a valuable tool in defining probable areas where a slick would impact on the coast.[9] Knowledge of the shoreline types, the beach sediment types, and the temporal variations in shoreline morphology are critical elements in predicting or estimating the distribution and persistence of an oil slick that reaches the coast. This information can be obtained either from existing data sources or from field studies and can be related to potential spill situations.

Beach dynamics, including spatial and temporal variations of the beach, are relatively well understood, particularly for sand coasts. Although the exact forcing functions and sediment pathways may be open to question, beach responses on sand and pebble-cobble coasts can be defined for given environmental conditions. Muddy coasts are less well known at present, primarily because of the difficulties of field study in this type of environment. The coastal geologist is in a position to provide contingency plans on specific sections of coast that will be valuable in determining the impact of oil on the shore, and to assess the effects of various cleanup techniques in terms of beach stability and sediment replenishment. The latter point is of great importance inasmuch as application of unsuitable techniques may lead to more damage than would have been caused by the oil alone. This is particularly important in areas of limited sediment supply to the beach and where a beach acts as protection for unconsolidated backshore cliffs.

It is well known that the type of oil and the nature of the sediments are important in predicting such factors as the depth to which oil will penetrate a beach. Many other parameters must be considered also in order to estimate the effects of a spill on different sections of coast. Longshore currents, tidal range, and levels of wave energy will affect the nature of the contamination as much as the type of oil or the size of the sediments. These parameters vary considerably along shore even on very short sections of coast, thus making the development of effective local contingency plans more difficult.

The examples from eastern Canada illustrate the variety of conditions that can face a cleanup manager. The development of local contingency plans[10] requires not only the organization of prepared personnel with defined responsibilities but also an adequate knowledge of the site conditions. Reconnaissance studies of high-risk coasts can provide this information which then can be presented in a format suitable for use by field personnel.

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13. ABSTRACT

Planning for a cleanup operation of the shore zone requires consideration of the physical nature of the coast (including the sediment types), wave energy levels, and tidal range. Beaches exist in a dynamic state and are continuously changing in response to littoral processes. In addition to these temporal variations, there is frequently considerable variability of shoreline types and process characteristics within a small region. In eastern Canada, contingency planning must cover rocky shorelines, sand beaches, and muddy coasts. There also is a wide range of littoral process environments, from the exposed Atlantic coast to the sheltered Bay of Fundy, which has tidal ranges on the order of 10 to 15 meters. Three examples from eastern Canada illustrate the variability of shorelines and processes in the context of cleanup planning.

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